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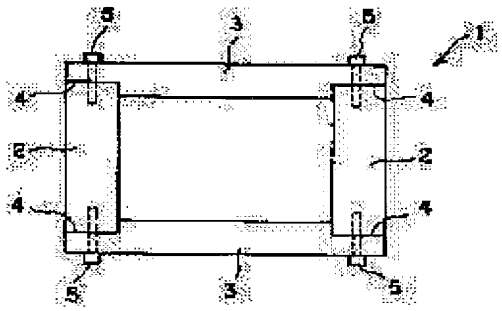
(54) CASTING MOLD FOR SOLIDIFICATION REFINING OF METAL SILICON

(57)Abstract:
PROBLEM TO BE SOLVED: To prevent failure of binding bolts of a graphite casting mold and the clearances of joints by forming first side plates forming the two opposite surfaces of erecting walls on four sides as thick rectangular plates, forming second side plates for forming the other opposite two surfaces as plates having L-shaped notches at both ends and fixing these second side plates to the first side plates by means of the binding bolts.
SOLUTION: The first side plates 2 are formed as the thick rectangular plates. The second side plates 3 are formed as the plates which have the L-shaped notches 4 to be pressed to the end faces and inner flanks of the first side plates 2 at both ends and are smaller in thickness than the first side plates. The first side plates 2 are fixed by the binding bolts penetrating the plates from the rear surfaces of the L-shaped notches 4. The first side plates 2 are large in the thickness and the second side plates 3 are smaller in the thickness than the same and, therefore, the second side plates 3 are more liable to be deformed and the expansion in the transverse direction of silicon is larger on the second side plates 3 side than on the first side plates 2, by which bend is generated in the second side plates 3. At this time, the tensile force in the axial direction of the binding bolts is countered as reaction and the occurrence of the failure of the bolts by the shearing force perpendicular to the bolt axes is averted.



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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] The 2nd side plate which forms the second page which the 1st side plate which forms the second page which a set-up wall counters in the mold made from a graphite which has the set-up wall of the fourth page and a bottom plate is used as a thick plate rectangle plate, and others counter Mold for metal silicon coagulation purification characterized by fixing to the 1st side plate with the binding bolt which has to ends L type notching which said the 1st end face and medial surface of a side plate contact, and is penetrated from the tooth back of this L type notching.
[Claim 2] Mold for metal silicon coagulation purification according to claim 1 characterized by forming a release agent layer in a mold inner surface.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the structure of the mold made from a graphite of having the set-up wall of the fourth page, and a bottom plate, about the mold for metal silicon coagulation purification in which the ingot of the semi-conductor silicon used for a solar battery etc. is cast.
[0002]
[Description of the Prior Art] As a manufacturing technology of polycrystalline silicon, conventionally to JP,62-108515,A Graphite plate manufacturing is used for mold and, similarly this graphite plate manufacturing is fixed with the screw made from a graphite. To the inner surface of mold The oxide of silicon, The simple substance of a nitride and carbide or two or more sorts of mixture are applied, and the polycrystalline silicon manufacture approach which can be taken out from mold is indicated, without the silicon which carried out cooling coagulation adhering to the inner surface of mold, when pouring in the fused silicon and carrying out cooling coagulation.
[0003] With the technique indicated by above-mentioned JP,62-108515,A, there is a problem that the binding bolt which is fixing mold is damaged by the cubical expansion at the time of silicon solidifying. namely, the consistency of silicon — a solid state — 2.33 g/cm3 and a melting condition — 2.5 g/cm3 it is — 7% of cubical expansion is produced at the time of the coagulation of silicon. For this reason, in manufacturing the ingot of silicon, it misses expansion upwards using the one direction coagulation approach made to solidify from the mold lower part, but even if such, lateral expansion arises, and shearing stress may be applied and damaged in the binding bolt of the graphite side plate of the mold fixed with the binding bolt. If a binding bolt is damaged, the combination section of the graphite side plate of mold will become loose, and there is a problem that the leakage of melting silicon arises from the combination section.
[0004] Moreover, the technique of pouring melting silicon into the mold which the bottom plate made from a graphite and the side plate of four sheets made from a graphite filed mutually to JP,6-144824,A, and was fixed with the bolt, carrying out cooling solidification, and manufacturing the ingot of polycrystalline silicon is indicated. Applying silicon dioxide powder to the inner surface of the side plate of said mold by the thickness of 0.5mm or more, and applying silicon nitride powder to the top face of said silicon dioxide spreading layer 0.35mm or more further is indicated by this technique. However, these techniques have not prescribed at all the method of the immobilization which files the thickness of a side plate, and a side plate and is fixed with a bolt.
[0005]
[Problem(s) to be Solved by the Invention] As mentioned above, in the mold for metal silicon coagulation purification, when an upper part one direction is made to solidify silicon from the mold lower part, a silicon ingot expands 0.9-1mm in a longitudinal direction in a horizontal section. In order to prevent breakage of the binding bolt which is assembling mold by this expansion, silicon dioxide powder etc. is applied to the inner surface of mold, and this spreading film extends, and thickness absorbs the expansion at the time of the coagulation of silicon, and he is trying to become thin and to serve as expansion relaxation material. Although the coagulation temperature of silicon is 1410 degrees C, since silicon dioxide powder will be in a half-melting condition above 1200 degrees C, the expansion at the time of the coagulation of silicon is absorbed. However, when shearing force acts on a binding bolt, it files in spite of this cure, and there is much breakage of a bolt. Moreover, when a clearance is generated at the joint of mold by expansion of silicon, there is a problem which the leakage of silicon produces.
[0006] This invention prevents the breakage of a binding bolt and generating of the clearance between joints in the mold for metal silicon coagulation purification in which it is the mold made from a graphite which has the set-up wall of the fourth page, and a bottom plate, and the ingot of the semi-conductor silicon for solar batteries is cast, and aims at offering the structure of the mold which solved the above-mentioned problem.
[0007]
[Means for Solving the Problem] The 2nd side plate which forms the second page which the 1st side plate with which this invention forms the second page which a set-up wall counters in the mold made from a graphite which has the set-up wall of the fourth page and a bottom plate is used as a thick plate rectangle plate, and others counter The mold for metal silicon coagulation purification characterized by fixing to the 1st side plate with the binding bolt which has to ends L type notching which said the 1st end face and medial surface of a side plate contact, and is penetrated from the tooth back of this L type notching is offered.
[0008] In addition, if the release agent layer is formed at the inner surface, the stress by the expansion at the time of the coagulation of silicon can be eased to the above-mentioned mold, and it is still more suitable for it. as a release agent — Si3 N4 and SiO2 independent in powder — or — if a laminating is carried out and it uses — good — the thickness of a release agent layer — the magnitude of mold etc. — responding — 0.5-1.0mm — then, it is good.
[0009]
[Embodiment of the Invention] With reference to a drawing, the gestalt of operation of this invention is explained below. First, the conventional technique is explained. Drawing 2 is the top view of the conventional mold 1 for metal silicon coagulation purification. The fourth page of the set-up wall 11 of the fourth page is altogether formed in isomorphism and this thickness. Drawing 3 is the explanatory view showing the condition that the force 13 by expansion of silicon is acting on the set-up wall of one side 11a. According to the force 13 by expansion of this silicon, binding bolt 12a of the end of set-up wall 11a receives a tensile load, and bolt 12b of the other end receives shearing load. Since the shear proof stress of a bolt is smaller than tension proof stress, binding bolt 12b has a

large possibility of resulting in breakage. Moreover, since a difference is in the reaction force of the ends of side plate 11a to the force 13 by expansion of silicon, a twist arises in side plate 11a. For this reason, in order to repeat and use this mold, it is necessary to thicken thickness of a side plate.

[0010] Drawing 1 is the top view of the example of this invention. Let the 1st side plate 2 which forms the second page which a set-up wall counters be a thick plate rectangle plate in this invention. The 2nd side plate 3 which forms the second page which others counter has to ends the L type notching 4 which the 1st end face and medial surface of a side plate 2 contact, and uses it as a thin plate thicker than the 1st side plate 2. And the 1st side plate 2 was fixed with the binding bolt 5 which penetrates a plate from the tooth back of the L type notching 4. The 1st side plate 2 has thick thickness, since the 2nd side plate 3 was used as thin meat compared with this, the way of the 2nd side plate is easy to deform, expansion of the longitudinal direction of silicon expands more greatly [the 2nd side plate 3 side] than the 1st side plate 2 side, and the 2nd side plate 3 produces deflection. At this time, as for the binding bolt 5 which is assembling mold, the bolt axial-tension force opposes as reaction force of expansion force. Therefore, it is lost that the reaction force which resists expansion force is based on shearing force right-angled to a bolt shank like the conventional technique. Therefore, a bolt is not damaged by shearing. Moreover, since the binding bolt is pressing the plane of composition of side plates from the tooth back of L type notching and the press direction of this binding bolt has opposed in the expansion direction of silicon, the aperture of the plane of composition by expansion of silicon is not produced. Therefore, the leakage of silicon does not arise, or a plate is twisted and a plane of composition does not deform. In addition, the force concerning the bolt by expansion of silicon can be decreased by applying a release agent to an inner surface.

[0011] Moreover, although the mold of this invention becomes heavy-gage [the 1st side plate] to the conventional mold, as the whole, it can decrease the weight of a side plate and becomes long lasting.

[0012]

[Example] The example of this invention shown in the conventional example shown in drawing 2 and drawing 1 was compared. Example Dimension Side plate 2:200mmx300mmx thickness 50mmx2 sheet side plate 3:280mmx300mmx thickness 30mmx2 sheet binding bolt : 10mmphix die-length 40mmx20 ** Example of a comparison The dimension of a side plate 11: 250mmx200mmx thickness 50mmx4 sheet Binding bolt : 10mmphix die-length [of 50mm] x20 this example, The example of a comparison is Si3 N4 as a release agent. It applied 0.5mm in thickness. Casting by the one direction coagulation of silicon was performed 10 times using these washings. In the conventional example, they were one exchange of five breakages on a bolt, a bolt, and a side plate, and one silicon leakage. In the example, breakage on a bolt, breakage on mold, and silicon leakage were not accepted at all.

[0013]

[Effect of the Invention] According to this invention, breakage of the binding bolt used for graphite mold is lost, therefore it files, the repetition activity of a bolt is attained, and activity cost decreases, and the leakage of the silicon from mold becomes that there is nothing. Furthermore, since the amount of the release agent applied to the inner surface of mold can be decreased, the affix of the front face of a silicon ingot also decreases, the manufacture yield of polycrystalline silicon improves, and reduction of a manufacturing cost is attained.

[0014] Since the screw stop of one side plate is carried out in the direction which opposes in the expansion direction of silicon, it can make a plate thin, it can make it thinner than the conventional mold as the whole, and, moreover, becomes long lasting.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the top view of the mold of an example.
[Drawing 2] It is the top view of the mold of the conventional example.
[Drawing 3] It is the explanatory view of the conventional example.
[Description of Notations]
1 Mold
2 1st Side Plate
3 Side Plate of Size 2
4 L Type Notching
5 Binding Bolt
11 Side Plate
12, 12a, 12b Binding bolt
13 Force by Expansion of Silicon

[Translation done.]

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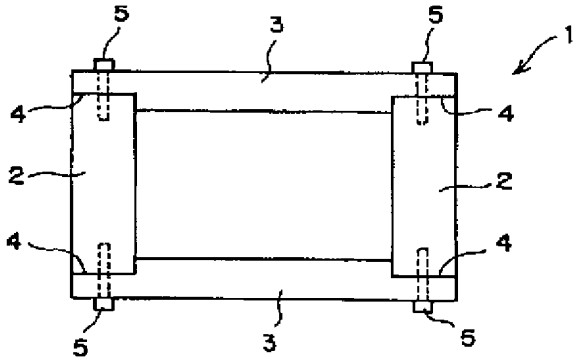
(54)【発明の名称】　金属シリコン凝固精製用鋳型

(57)【要約】
【課題】四面の立設壁及び底板を有する、太陽電池用の半導体シリコンの凝固精製用鋳型における、綴じボルトの破損や継目の隙間の発生を防止する。
【解決手段】立設壁の対向する二面を形成する第１の側板２は厚板矩形板とし、他の対向する二面を形成する第２の側板３は、第１の側板２の端面及び内側面が当接するＬ型切欠４を両端に有し、第１の側板２より肉厚の薄い板とする。Ｌ型切欠４の背面から板を貫通する綴じボルト５で第１の側板２を固定する。



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【特許請求の範囲】

【請求項１】　四面の立設壁と底板とを有する黒鉛製鋳型において、立設壁の対向する二面を形成する第１の側板は厚板矩形板とし、他の対向する二面を形成する第２の側板は、前記第１の側板の端面及び内側面が当接するＬ型切欠を両端に有し該Ｌ型切欠の背面から貫通する緩じボルトで第１の側板に固定したことを特徴とする金属シリコン凝固精製用鋳型。

【請求項２】　鋳型内面に離型剤層を形成したことを特徴とする請求項１記載の金属シリコン凝固精製用鋳型。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、太陽電池等に用いられる半導体シリコンのインゴットを鋳造する金属シリコン凝固精製用鋳型に関し、四面の立設壁及び底板を有する黒鉛製鋳型の構造に関するものである。

【０００２】

【従来の技術】従来、多結晶シリコンの製造技術として、例えば、特開昭６２－１０８５１５号公報には、鋳型に黒鉛製板を用いこの黒鉛製板を同じく黒鉛製ネジで固定し、鋳型の内面にシリコンの酸化物、窒化物、炭化物の単体または２種以上の混合物を塗布し、溶融したシリコンを注入して冷却凝固させた際、冷却凝固したシリコンが鋳型の内面に付着することなく、鋳型より取り出すことができる多結晶シリコン製造方法が開示されている。

【０００３】上記特開昭６２－１０８５１５号公報に開示された技術では、シリコンが凝固する際の体積膨張によって、鋳型を固定している緩じボルトが破損するという問題がある。すなわち、シリコンの密度は固体状態で２．３３ｇ／ｃｍ³、溶融状態で２．５ｇ／ｃｍ³であり、シリコンの凝固時には７％の体積膨張を生じる。このため、シリコンの鋳塊を製造する場合には、鋳型下部から凝固させる一方向凝固方法を用い、膨張を上方へ逃がすようにするが、このようにしても、横方向の膨張が生じ、緩じボルトで固定している鋳型の黒鉛側板の緩じボルトに剪断応力がかかり破損することがある。緩じボルトが破損すると鋳型の黒鉛側板の組み合わせ部がルーズになり、組み合わせ部から溶融シリコンの漏れが生じるという問題がある。

【０００４】また、特開平６－１４４８２４号公報には黒鉛製の底板と黒鉛製の４枚の側板が、互いに緩じボルトで固定された鋳型に溶融シリコンを注入し、冷却固化して多結晶シリコンの鋳塊を製造する技術が記載されている。この技術では、前記鋳型の側板の内面に二酸化珪素粉末を０．５ｍｍ以上の厚さで塗布し、さらに前記二酸化珪素塗布層の上面に窒化珪素粉末を０．３５ｍｍ以上塗布することが記載されている。しかしこれらの技術では、側板の厚さや側板を緩じボルトで固定する固定の仕方について何ら規定していない。

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【０００５】

【発明が解決しようとする課題】上述のように、金属シリコン凝固精製用鋳型ではシリコンを鋳型下部から上方一方向に凝固させた場合、シリコン鋳塊は水平断面で横方向に０．９～１ｍｍ膨張する。この膨張により鋳型を組み立てている緩じボルトの破損を防止するために、二酸化珪素粉末等を鋳型の内面に塗布し、この塗布膜が延伸して厚みが薄くなり、シリコンの凝固時の膨張を吸収して膨張緩和材となるようにしている。シリコンの凝固温度は１４１０℃であるが、二酸化珪素粉末は１２００℃以上で半溶融状態となるので、シリコンの凝固時の膨張を吸収する。しかし、緩じボルトにせん断力が作用する時には、この対策にも拘らず緩じボルトの破損が多い。また、シリコンの膨張により鋳型の継目に隙間が生ずるとシリコンの漏れが生ずる問題がある。

【０００６】本発明は、四面の立設壁及び底板を有する黒鉛製鋳型であって、太陽電池用の半導体シリコンのインゴットを鋳造する金属シリコン凝固精製用鋳型における、緩じボルトの破損や継目の隙間の発生を防止し、上記問題を解決した鋳型の構造を提供することを目的とするものである。

【０００７】

【課題を解決するための手段】本発明は、四面の立設壁と底板とを有する黒鉛製鋳型において、立設壁の対向する二面を形成する第１の側板は厚板矩形板とし、他の対向する二面を形成する第２の側板は、前記第１の側板の端面及び内側面が当接するＬ型切欠を両端に有し該Ｌ型切欠の背面から貫通する緩じボルトで第１の側板に固定したことを特徴とする金属シリコン凝固精製用鋳型を提供するものである。

【０００８】なお、上記鋳型には内面に離型剤層を形成しておくとシリコンの凝固時の膨張による応力を緩和することができ、さらに好適である。離型剤としてはSi_3N_4、SiO_2粉を単独又は積層して用いるとよく、離型剤層の厚さは、鋳型の大きさ等に応じて０．５～１．０ｍｍとすればよい。

【０００９】

【発明の実施の形態】以下図面を参照して本発明の実施の形態を説明する。先ず、従来技術について説明する。図２は従来の金属シリコン凝固精製用鋳型１の平面図である。四面の立設壁１１は四面ともすべて同形、同肉厚に形成されている。図３はその一辺の立設壁１１ａにシリコンの膨張による力１３が作用している状態を示す説明図である。このシリコンの膨張による力１３によって、立設壁１１ａの一端の緩じボルト１２ａは引張り荷重を受け、他端のボルト１２ｂは、せん断荷重を受ける。ボルトは引張り耐力よりもせん断耐力の方が小さいから、緩じボルト１２ｂは破損に至るおそれが大きい。また、シリコンの膨張による力１３に対して側板１１ａの両端の反力に差があるので側板１１ａに捩じれが生じ

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る。このために、この鋳型をくり返し使用するには、側板の肉厚を厚くする必要がある。

【００１０】図１は本発明の実施例の平面図である。本発明では、立設壁の対向する二面を形成する第１の側板２は厚板矩形板とする。他の対向する二面を形成する第２の側板３は、第１の側板２の端面及び内側面が当接するＬ型切欠４を両端に有し、第１の側板２より肉厚の薄い板とする。そして、Ｌ型切欠４の背面から板を貫通する緩じボルト５で第１の側板２を固定するようにした。第１の側板２は肉厚が厚く、第２の側板３はこれに比べて薄肉としたから、第２の側板のほうが変形し易く、シリコンの横方向の膨張は、第１の側板２側よりも第２の側板３側に大きく膨張し、第２の側板３は曲がりを生ずる。このとき、鋳型を組立てている緩じボルト５は、ボルト軸方向引張り力が膨張力の反力として対抗する。従って、従来技術のように、膨張力に抵抗する反力がボル＊

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＊ト軸に直角な剪断力によることはなくなる。従ってボルトが剪断により破損することはない。また、側板同士の接合面は、緩じボルトがＬ型切欠の背面から押圧しており、この緩じボルトの押圧方向はシリコンの膨張方向に対抗しているので、シリコンの膨張による接合面の開きは生じない。従って、シリコンの漏れが生じたり、板が捩じれて接合面が変形することもない。なお、離型剤を内面に塗布することにより、シリコンの膨張によるボルトに掛る力を減少させることができる。

【００１１】また、本発明の鋳型は、従来の鋳型に対して、第１の側板は厚肉となるが、全体としては、側板の重量を減少させることができ、しかも長寿命となる。

【００１２】

【実施例】図２に示す従来例と図１に示す本発明の実施例とを比較した。

実施例

寸法　側板２：２００ｍｍ×３００ｍｍ×厚さ５０ｍｍ×２枚

側板３：２８０ｍｍ×３００ｍｍ×厚さ３０ｍｍ×２枚

緩じボルト　：１０ｍｍφ×長さ４０ｍｍ×２０本

比較例

側板１１の寸法：２５０ｍｍ×２００ｍｍ×厚さ５０ｍｍ×４枚

緩じボルト　：１０ｍｍφ×長さ５０ｍｍ×２０本

実施例、比較例共、離型剤としてＳｉ，Ｎ，を厚さ０．５ｍｍ塗布した。これらの塗型を用い、シリコンの一方向凝固による鋳造を１０回行った。従来例では、ボルトの損傷５回、ボルト及び側板の取替１回、シリコン漏洩１回であった。実施例では、ボルトの損傷、鋳型の損傷、シリコン漏洩は全く認められなかった。

【００１３】

【発明の効果】本発明によれば、黒鉛鋳型に使用する緩じボルトの破損がなくなり、従って緩じボルトのくり返し使用が可能となり、使用コストが減少し、また、鋳型からのシリコンの漏れが皆無となる。さらに、鋳型の内面に塗布する離型剤の量を減少させることができるから、シリコン鋳塊の表面の付着物も少なくなり、多結晶シリコンの製造歩留りが向上し、製造コストの低減が可能となる。

【００１４】一方の側板はシリコンの膨張方向に対抗す＊

＊る方向にネジ止めするので板を薄くすることができ、全体としては従来の鋳型より薄くすることができ、しかも長寿命となる。

【図面の簡単な説明】

【図１】実施例の鋳型の平面図である。

【図２】従来例の鋳型の平面図である。

【図３】従来例の説明図である。

【符号の説明】

１　鋳型

２　第１の側板

３　大２の側板

４　Ｌ型切欠

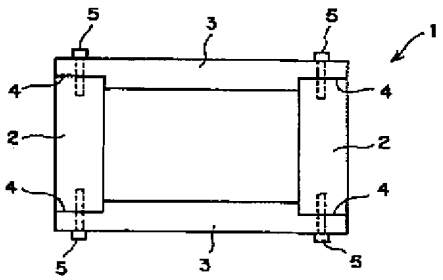
５　緩じボルト

１１　側板

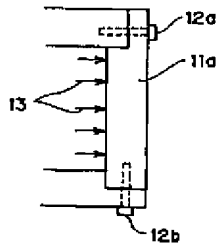
１２、１２ａ、１２ｂ　緩じボルト

１３　シリコンの膨張による力

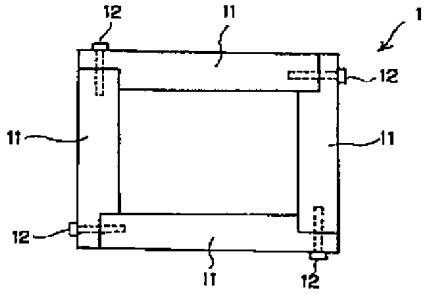
【図１】



【図３】



【図２】



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